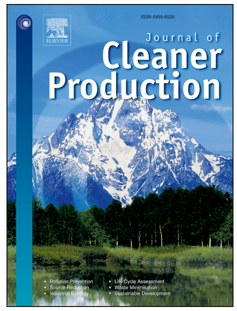

Green supply chain management practices: Multiple case studies in the Brazilian home appliance industry

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GREEN SUPPLY CHAIN MANAGEMENT PRACTICES: *Multiple case studies in the Brazilian home appliance industry*

ABSTRACT

Leading manufacturers in developed countries generally implement green practices and have high levels of environmental awareness. However, it is uncertain which practices are implemented and how they are implemented in the home appliance sector of emerging countries such as Brazil. The purpose of this study is to identify and analyze the practices of green supply chain management adopted by home appliance manufacturers. To analyze green practices in this industry, 5 manufacturers and 2 professional associations were used as case studies; this approach provided in-depth interviews about internal environmental management, reverse logistics, green purchasing, eco-design, life cycle assessment, waste management, and green manufacturing. Waste management was the most widely used technique among the research participants, and green purchasing and life cycle assessment practices were less widespread. Significant differences in the adoption of certain green supply chain management (GSCM) dimensions were observed between companies with ISO 14001 certification and non-certified companies. Suggestions for further developing GSCM in the home appliance industry are also presented.

KEY WORDS

Green supply chain management, Green practices, Home appliance, Electrical–electronic industry.

1. INTRODUCTION

Changes in environmental awareness over the last few years, including legal requirements, pressure from customers, the need for waste management, reuse of materials and packaging, product recovery, and changes in product projects, have influenced supply chain management. Thus, companies are increasingly linking green practices with corporate strategy. Green manufacturing, or more precisely, green supply chain manufacturing, has attracted interest among researchers and practitioners over the past two decades (Dubey et. al, 2015). Although the importance of these practices can be traced back to the late 1960s (Sarkis et al., 2011), many authors (Fahimnia et al., 2015; Hassini et al., 2012; Sheu and Talley, 2011) stress the importance of studies that focus on practical applications and industry-specific research.

Moreover, recent practical evidence is provided from the latest United Nations Global Compact sustainability survey of leading companies. Studies regarding which green practices are conducted and in which contexts they are implemented are lacking in emerging markets such as Brazil (Seuring and Gold, 2013).

Pressure from stakeholders, such as government regulators, community activists, non-governmental organizations and global competition, are triggering factors for companies to adopt a certain level of commitment to green and sustainable practices (Hassini et al., 2012).

Brazil has companies that are hesitant to commit to sustainability issues as long as they are not forced to do so by law. Some subsidiaries or exporters have enacted regulations to control environmental impacts throughout the product life cycle. European Union directives such as the Restrictions of Hazardous Substances (RoHS) from the supplier side and the Waste Electrical and Electronic Equipment (WEEE) for product end-of-life provide substantial economic market pressure because many of the electronic and electrical appliances exported from Brazil are sold to the European community.

In 2010, Brazil introduced a new solid waste management regulatory policy to internalize costs and liabilities to manufacturers and consumers while establishing and promoting reverse logistics and product and material stewardship.

The closed-loop supply chain requirements for material and product take-back include developing processing systems for a broad variety of consumer materials. These additional consumer-based materials include pesticide packaging; batteries, tires, lubricants and their respective packaging; light bulbs; and electrical–electronic equipment discarded by consumers (De Sousa Jabbour et al., 2014, p. 8).

Although a large number of studies have concerned green supply chain management (GSCM) in the electrical and electronic industry (Anjos et al., 2012; Ayvaz et al., 2015; Georgiadis and Besiou, 2008; Georgiadis and Besiou, 2010; Manhart, 2011), a limited number of studies have focused specifically on the home appliance sector and the specific practices of green supply chain management that are being used. This paper seeks to fill these gaps by identifying and analyzing the practices of green supply chain management adopted by home appliance manufacturers in order to prepare for the new regulation that took effect in 2014. This study also contributes some managerial implications.

To achieve this goal, multiple case studies were researched using data collected through face-to-face semi-structured interviews with senior representatives from the main manufacturers located in Brazil.

The context of sustainability is a process of organizational transformation. Therefore, case studies are useful because they help to explain how a process occurs (Pagell and Shevchenko, 2014).

This work focuses on the study of GSCM practices adopted by local companies, which are consequently extended to their suppliers and customers (Vachon and Klassen, 2006). Seuring and Müller (2008) argued that it is important for policy- and decision-makers to understand which factors support and trigger the initiatives of green supply chain management.

Given the emphasis on integrating sustainability and supply chain management, it is unsurprising that no consensus definition for a green and sustainable supply chain exists. Ahi and Searcy (2013) found a total of 22 definitions for green supply chain management and 12 definitions for sustainable supply chain management. As a result, questions persist on how these concepts can be applied in practice (Ahi and Searcy, 2015).

This paper is divided into five sections, including the introduction. The second section provides a literature review that highlights the main practices of green supply chain management. In the third section, the methodological procedures are presented. In the fourth section, the results are presented and discussed, and finally, the conclusions are shown in section five.

2. LITERATURE REVIEW OF GSCM PRACTICES

Conventional supply chain management (SCM) practices have focused only on pre-manufacturing, manufacturing and use. The post-use stage of a product life cycle is often addressed on a piecemeal basis and only when such practices deliver economic benefits (Badurdeen et al., 2009). Nevertheless, the need to include aspects of sustainability in industrial activities has been increasingly recognized. According to Jayal et al. (2010), efforts to make manufacturing more sustainable must holistically account for the product, process and systems perspectives. At the process level, energy and resource consumption, toxic wastes, and occupational hazards need to be reduced. At the system level, all aspects of the entire supply chain need to be considered, taking into account all of the major life cycle stages—pre-manufacturing, manufacturing, use and post-use—over multiple life cycles (Jayal et al., 2010, p. 144).

In this research, we conducted a literature review from the green practice perspective. In a bibliometric study, Srivastava (2007) found more than 1500 papers about GSCM and classified these papers into three groups: green design (eco-design and life cycle assessment), green operations (green manufacturing and remanufacturing, reverse logistics and waste management) and the importance of GSCM.

In another study, Zhu et al. (2008) described the implementation of green practices.

The green practices described by Srivastava (2007) and Zhu et al. (2008) were selected to delimit this study because the first was a compilation of the most often described practices in the literature and the latter was an empirical study in China, which is a developing country similar to Brazil (see figure 1).

The practice of performance evaluation was also considered. Investment recovery was not considered for this industry, and cooperation with customers appears in many practice implementations, so it was analyzed in their respective contexts.

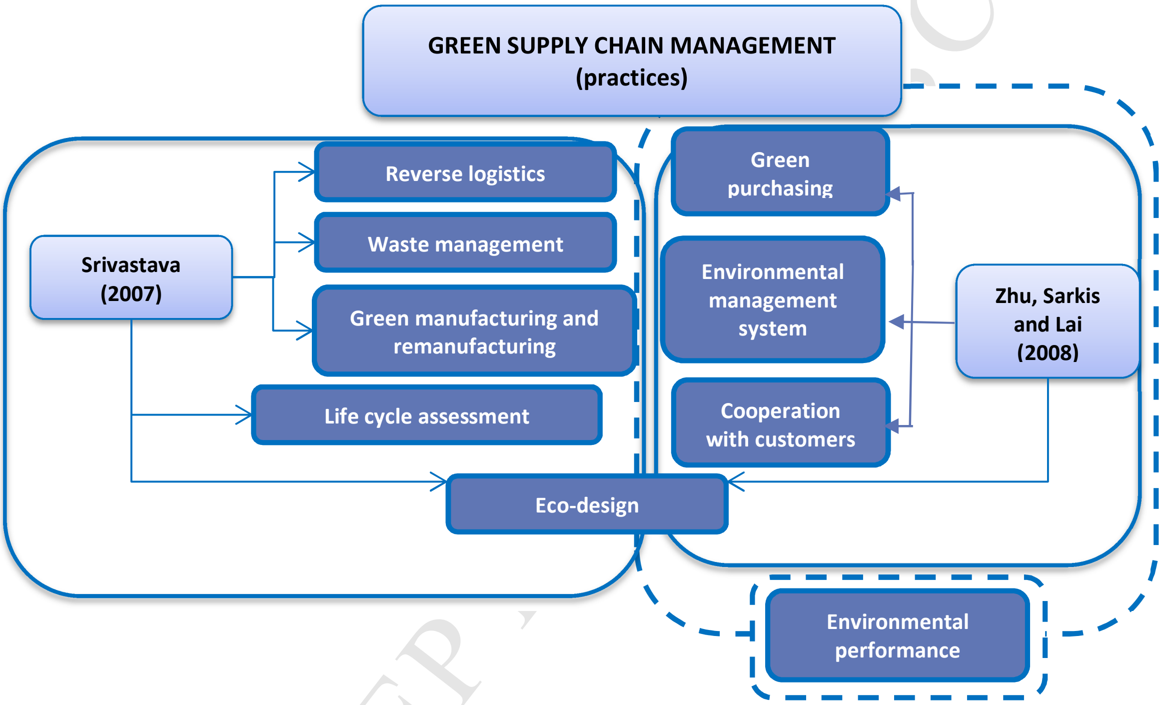

Figure 1 - GSCM practices considered in this study
Source: Authors

Reverse logistics allows expired or contaminated products as well as products that are at the end of their life cycles to be withdrawn from the market. The flow of material return in the context of reverse logistics is classified by Fleischmann et al. (2001) into four categories: return at the end of use (for already consumed or used products), commercial return (products returned due to customer dissatisfaction), reusable packaging and subproducts (products that do not present conditions of use), and cargo unitization (pallets and reusable boxes).

According to Agrawal et al. (2015, p. 77), used or returned products are collected after their acquisition and are inspected for sorting into the different categories. The next step is to assign them to repair, remanufacturing, recycling, reuse or final disposal, depending on the decision to either recapture their value or dispose of them. The key processes are product acquisition, collection, inspection/sorting, and disposal. Because product returns are uncertain in terms of time, quantity and quality, their acquisition is important for the success of reverse logistics (Fleischmann et al., 2001). In the Brazilian electro-electronics industry, legislation demands the practice of reverse logistics through the Solid Waste National Policy.

Waste management refers to the treatment of solid wastes, liquid wastes, or atmospheric emissions prior to their release to the environment. Sarkis (2003) argued that the five main elements that impact the management of wastes generated along the supply chain are reduction, reuse, remanufacture, recycling, and alternative waste destinations (ordered from the least to most harmful environmental impact). Srivastava (2007) stated that waste management consists of three actions: prevention, pollution reduction, and final disposal.

Furthermore, Jayal et al. (2010) argued for the need to move beyond the traditional 3R concept (reduce, reuse, recycle) to a 6R concept (reduce, reuse, recover, redesign, remanufacture, recycle). “Reduce” refers to the reduced use of resources in pre-manufacturing stages, reduced use of energy and materials during manufacturing and the reduction of waste during the use stage. “Reuse” refers to the reuse of a product or its components after its first life cycle. “Recycle” involves the process of converting material that would otherwise be considered waste into new materials or products. “Recover” is related to the process of collecting products at the end of use and disassembling, sorting and cleaning the products for use in subsequent product life cycles. “Redesign” simplifies the post-use processes. “Remanufacture” involves the re-processing of used products for restoration to their original state or a like-new form through the reuse of as many parts as possible without loss of functionality (Jayal et al., 2010, p. 145).

All of these processes are considered green manufacturing; they are characterized as manufacturing methods that efficiently use raw materials with less environmental impact while producing moderate to no waste or pollution (Ninlawan et al., 2010).

One way to minimize the product and process environmental impacts before the manufacturing process is to develop eco-friendly products. The term “eco-design” has been broadly used in the literature to indicate products that meet environmental criteria.

Pigosso et al. (2013) stated that eco-design is a proactive environmental management approach that integrates environmental issues into product development and related processes such as manufacturing, marketing, and procurement. According to Zhu et al. (2008), eco-design needs to simultaneously consider the functionality of the product and minimize the environmental impacts of its life cycle.

Studies show that 80% of the costs and environmental impacts of a product are defined at the design stage through product specifications, packaging, and market positioning (Boothroyd et al., 2002). Therefore, the design stage is the mechanism through which an efficient product with appropriate pricing and environmental performance is obtained (Rebitzer, 2002).

According to Boons and Ludeke-Freund (2013), disruptive, incremental and systemic innovations are especially relevant if there is a link between sustainable innovation and economic performance. One sustainable innovation tool is Design for Environment (DfE), which together with life cycle assessment (LCA) should be essential for relating the design of products to their environmental sustainability (Eppinger, 2011).

Based on LCA, introducing environmental concerns into product design favors managing the end of the life cycle (Beamon, 2008). LCA can be used as a complement to eco-design implementation. From the product's life cycle assessment, characteristics such as environmental and health safety are evaluated and integrated through design, influencing the development of new products and processes. LCA involves product safety, management of environmental risks, resource conservation, pollution prevention, and waste management (Srivastava, 2007).

Life cycle assessment is a tool for reducing environmental damage in the supply chain by measuring and analyzing the environmental effects of a product throughout its life cycle in terms of the consumption of materials and energy and the wastes produced (Pereira de Carvalho and Barbieri, 2012). In this way, all stages of the supply chain that contribute to environmental degradation are evaluated, from the use of raw material to the final disposal of the product, adding occasional reuse stages (Tsoulfas and Pappis, 2006).

From the same perspective, Jayal et al. (2010, p. 145) stated that LCA attempts to quantify the overall environmental and economic impact in terms of material and energy consumption and carbon footprint over the entire life cycle of a product, from material extraction to eventual disposal at the end of life.

Green procurement refers to procuring products or services that have a reduced environmental impact compared with other products or services that serve the same purpose or procuring products that meet certain predefined environmental criteria (Mosgaard, 2015, p. 264). Zsidisin and Siferd (2001) established green purchasing as a set of purchasing doctrines, actions, and relations adopted in response to concern for the environment. These concerns are associated with purchasing raw materials, evaluating suppliers throughout distribution, packaging, reuse, reduction of resources, recycling, and final disposal of the products.

To minimize their environmental impacts, companies have adopted environmental management systems as frameworks for integrating corporate environmental protection policies, programs, and practices. According to Guerrero-Baena et al. (2015), environmental management systems tend to be based on international standards such as ISO 14001.

González, Sarkis and Adenso-Días (2008) stated that a positive relation exists between companies that have ISO 14001 certification and the requirements designed for suppliers in relation to environmental questions. Thus, environmental responsibility spreads throughout the supply chain.

Finally, the measurement indicators for environmental performance not only are important for receiving a license to operate but also should involve different stakeholders' requirements to obtain a clear understanding of how sustainability has been taken into account (Hourneaux Jr. et al., 2014).

Environmental performance is related to reduced solid wastes, liquid wastes, and atmospheric emissions and also limits the consumption of resources and dangerous or toxic materials, restricts the frequency of environmental accidents, and improves the health of employees and the community as a whole (Eltayeb et al., 2011).

3. RESEARCH PROCEDURES

This research can be considered empirical and qualitative considering the characteristics presented by the multiple case study format. Yin (2014) stated that this method is particularly appropriate due to the contemporaneity of the content, the research question, and the impossibility of manipulating behaviors. This study is descriptive because it aims to analyze and register GSCM practices in organizations from the home appliance industry, uncovering events or phenomena that help to understand strategic questions without interfering in the events (Cervo and Bervian, 2002).

Eisenhardt (1989) argued that planning and conducting case studies must follow a set of steps. This study adopted the steps proposed by Stuart et al. (2002): defining the research question, developing instruments and selecting sites, gathering data, analyzing data and disseminating the research findings.

3.1 Defining the research question, constructs and research protocol

According to Eisenhardt (1989), this stage aims to provide the best basis for measuring the constructs. The constructs were measured by the dimensions presented in table 1, which were codified as proxies to increase the readability and clarity of the results presented in the figures and tables.

Table 1
Research Protocol

CONSTRUCTS/AUTHORS	CODES AND DIMENSIONS
Reverse Logistics Fleischmann et al. (2001) Agrawal et al. (2015)	RLout: Practices of reverse logistics with suppliers: return and/or replacement of defective products out of specification. RLpack: Practices of reverse logistics with suppliers: return of packaging materials such as pallets, plastic boxes, and containers. RLfin: Practice of reverse logistics for collecting finished products: products out of specification, malfunctioning, damaged in transportation, etc. RLend: Practice of reverse logistics for collecting finished products at the end of their lifespan or for recovery, remanufacturing, recycling or disposal.
Waste Management Badurdeen et al. (2009) Sarkis (2003)	WMclass: Characterization and classification (Class I, II, II A or B) of solid waste generated in the production process. WMdisp: Disposal of generated solid waste (marketing, recycling, reuse, or disposal) performed only in accredited and authorized companies for this purpose. WMplan: Plan for solid waste management (in compliance with the National Policy on Solid Waste). WMwater: Wastewater treated before disposal to the environment. WMatm: Atmospheric emissions treated before disposal to the environment.
Green Manufacturing and Remanufacturing Ninlawan et al. (2010) Rebitzer (2002)	GMRequip: Production equipment in regular operating conditions and installed according to the project (in terms of efficiency, resource consumption, etc.). GMRmaint: Preventive and predictive maintenance of equipment aiming at proper functioning and increased lifespan. GMRdisa: Practice of disassembly: method that aims at separating the finished product into its constituent parts with a view toward recycling and/or reuse, either total or partial. GMRproc: Practice of recycling and/or reuse of materials or failed components in the production process. GMRprod: Practice of recycling and/or reuse of materials or product components after the end of their lifespan.
Eco-Design Zhu et al. (2008) Eppinger (2011)	ECOprod: Project development of products considering their impacts to the environment (e.g., consumption of natural resources, use of materials/components recycled in production, generation of solid waste, liquid effluents, and air emissions, etc.) ECOproc: Project development of processes considering their impacts to the environment (e.g., consumption of natural resources, use of materials/components recycled in production, generation of solid waste, liquid effluents, and air emissions, etc.)
Life Cycle Assessment Beamon (2008) Pereira de Carvalho and Barbieri (2012) Jayal et al. (2010)	LCAproc: Analysis of the completion of the life cycle of products considering the impacts on the environment (this analysis includes all of the product's life cycle, including extraction, raw materials processing, production, distribution, use, reuse, maintenance, recycling, and final disposal). Impacts on the environment: consumption of natural resources, use of materials/components recycled in production, generation of solid waste, liquid effluents, and air emissions, etc. LCAprod: Analysis of the completion of the life cycle of processes considering the impacts on the environment (this analysis includes all of the process's life cycle, including extraction, raw materials processing, production, distribution, use, reuse, maintenance, recycling, and final disposal). Impacts on the environment: consumption of natural resources, use of materials/components recycled in production, generation of solid waste, liquid effluents, and air emissions, etc.
Green Purchasing Mosgaard (2015) Zsidisin and Siferd (2001)	GPmat: Purchasing environmentally friendly materials (recycled, biodegradable, or reusable products). GPIso: Suppliers with ISO 14001 certification. GPaudit: Environmental audits on suppliers of materials and services. GPpartner: Partnerships with suppliers seeking environmental solutions and/or development of environmentally friendly products.
Internal Environmental Management Guerrero-Baena et al. (2015) González, Sarkis and Adenso-Días (2008)	IEMcommit: Top management commitment to GSCM. IEMstaff: Staff cooperation for environmental improvements. IEMaudit: Internal environmental audit programs. IEMIso: ISO 14001 certification.
Environmental Performance	EPenergy: Reduction in energy consumption. EPwater: Reduction in water consumption.

Eltayeb et al. (2011) Hourneaux Jr. et al. (2014)	EPatm: Reduction in the generation of atmospheric emissions. EPwaste: Reduction in the generation of solid and liquid waste. EPprevention: Increase in expenses/investments aimed at prevention and preparedness in the event of environmental accidents. EPfines: Decrease in accidents and/or environmental fines. EPcomplaints: Decrease in community, government, and city hall complaints regarding environmental issues.
Drivers for GSCM Implementation Hsu et al. (2013) Diabat and Govindan (2011) Srivastava (2007) Zhu et al. (2008) Zhu et al. (2013) Govindan et al. (2014)	Environmental regulations Stakeholder and customer pressure Financial benefits Competitors Market trends Company image Environmental conservation Supply chain requirements Green innovation Internal motivations and employee demands
Barriers for GSCM Implementation Govindan et al. (2014)	Lack of technology Outsourcing Financial concerns Knowledge Involvement and support

The propositions that can be considered to represent the constructs for measurement purposes were established (Miguel, 2010). The theoretical assumptions underlying this study are the following:

P1. We assume that environmental regulations are the coercive pressures driving the implementation of GSCM in Brazil, similar to the case in China (Zhu et al., 2013).

P2. Customer involvement is the most important obstacle to GSCM adoption (Govindan et al., 2014).

P3. According to Zhu et al. (2008) and Srivastava (2007), GSCM practices include internal environmental management systems, green purchasing, cooperation with customers, eco-design and investment recovery, waste management, green manufacturing and remanufacturing, life cycle assessment and reverse logistics.

P4. Internal practices are generally adopted more often than external practices, and waste management is the most often adopted practice due to the National Policy on Solid Waste (De Sousa Jabbour et al., 2013; Jabbour, 2015).

3.2 Site selection and data collection

This study was based on multiple case studies with five companies that lead the home appliances market and two class associations. The companies were selected based on economic and market share importance. According to Eisenhardt (1989), considering between four and ten cases is appropriate.

Initially, 32 companies affiliated with the National Association of Producers of Electronic Goods were contacted. Among the associated home appliance manufacturers, five were willing to participate in the research, including two of the largest brands in the market sector: Whirlpool and Electrolux.

As a complement to this study, data collection also relied on two interviews, one with the executive manager of the Brazilian Association for Electro-Electronics and Home Appliances Recycling and the other with the manager of the Brazilian Association of Electronic Wastes. The interviews were conducted face-to-face at the plant or in the company office during the first half of 2014.

Table 2

Description of the companies studied and the data sources

COMPANY	NATIONALITY	SIZE	INTERVIEW	SECONDARY DATA
Whirlpool	American	Large	Position: Manager of Sustainability Duration: 3 hours	Sustainability report News from Internet portal Data from company's website
Electrolux	Swedish	Large	Position: Manager of Industrial Operations Duration: 2 hours	Sustainability report News from Internet portal Data from company's website
Elgin	Brazilian	Large	Position: Manager of Industrial Operations Duration: 1 h 30 min	News from Internet portal Data from company's website
Atlas	Brazilian	Large	Position: Manager of Industrial Operations Duration: 1 h 30 min	News from Internet portal Data from company's website
Mueller	Brazilian	Medium	Position: Manager of Industrial Operations Duration: 1 h 30 min	News from Internet portal Data from company's website

The constructs and variables of GSCM practices used in the research protocol were previously validated based on the opinions of specialists.

4. RESULTS AND DISCUSSION

The drivers for implementing green practices are related to market trends. However, an emerging market such as Brazil will follow legal requirements because, as seen in the interview discourse (table 3), companies must export products and also operate in the domestic market.

Table 3

Interview statements related to drivers and barriers for adoption of green practices

Whirlpool	[…] Whirlpool works within the concept of sustainable innovation, developing more sustainable products and processes considering social, economic and environmental aspects. […] the main barrier is the lack of environmental awareness by consumers who often base their purchases on price.
Electrolux	[…] our European capital origin favors the sustainability commitment, but the international and national regulations and marketing are the main drivers […] The barrier is related to the lack of environmental awareness by consumers.
Elgin	Elgin is worried about the planet's preservation and has recently launched three air conditioners developed with items less harmful to the environment. So we follow the market trends […] The main barrier is financial concerns […]
Atlas	[…] The National Solid Waste Policy was the great motivator for sustainable practices […] the impediment to implementing more practices is the cost […]
Muller	[…] we believe that the marketing differential is the main driver to implementing green practices, but this factor is related to the environmental criteria for exportation […] while suppliers, manufacturers, employees and customers do not have environmental awareness, it will be difficult to adopt green practices.

	The costs are another obstacle to implementing an internal environmental management such as ISO 14000.

Source: Research data

Similar to the findings of Govindan et al. (2014), the main barrier to implementing green practices is the high cost, but the cost is high because domestic consumers are not willing to spend more money on eco-friendly products. Domestic consumers are not necessarily unaware of sustainability, but if they are presented with the same products with the same performances, they will select the least expensive option. We found that the investment cost of adopting green practices, such as environmental management systems, are so high because of a lack of customer awareness and pressure regarding GSCM. Thus, manufacturers are ready to adopt green practices because they do not negatively impact profits.

Figure 2 shows that the most widely adopted GSCM practices in the Brazilian home appliance industry are green manufacturing and remanufacturing and waste management.

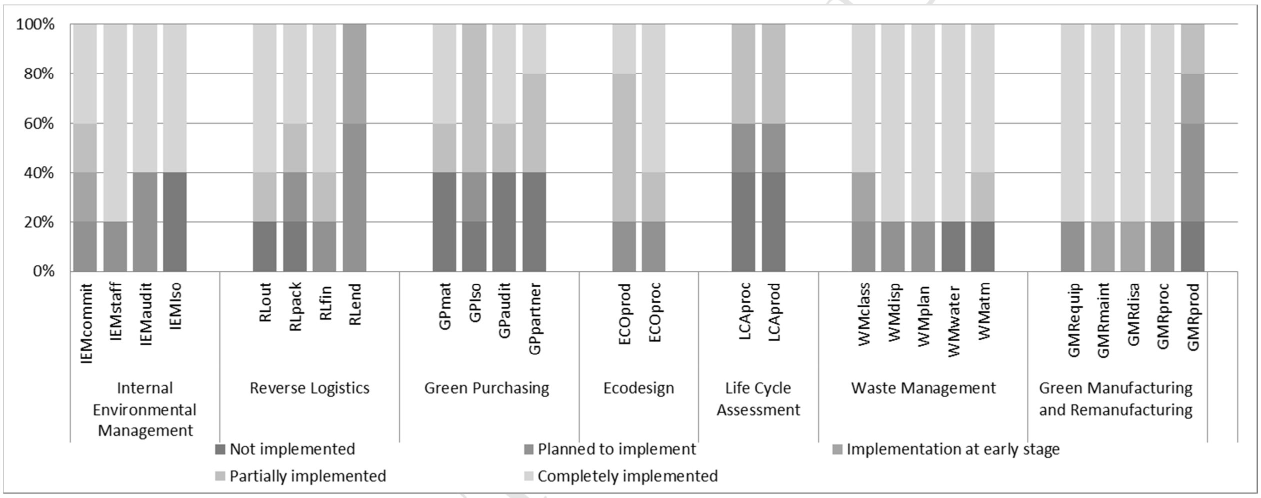

Figure 2 – The number of companies (as a percentage) that have applied green supply chain management practices
Source: Research data

The five firms that were interviewed reported that waste management practices are almost completely implemented because they are strongly associated with the present legislation regarding waste management, treatment, and disposal. In this research, companies have focused on efforts to minimize waste disposal to the detriment of other practices.

Related to the practice of green manufacturing and remanufacturing, many of the companies have their equipment properly installed according to their projects and in good working condition. These companies conduct preventive and predictive maintenance, focusing on their product performance and increasing their lifespan; they conduct disassembly of the finished products for posterior recycling and/or reuse; and they practice recycling and/or reuse of rejected materials or components in the manufacturing process.

Reinforcing the green manufacturing and remanufacturing green practice results, according to Franco and Filipim (2007), the installation and maintenance of equipment strongly influence productivity and environmental issues.

The practice of green purchasing had low implementation, considering the increased material cost and the limited number of qualified suppliers due to the demand for differentiated materials and components. The partnership between manufacturers and suppliers, in the search for environmental solutions, is a practice that still needs improvement.

Eco-design has been completely implemented at Electrolux for both products and processes. Electrolux has a project named Green Spirit in which all of the processes follow resource, residue and emissions reduction principles. Mueller seeks to develop products that minimize their impacts. Whirlpool implemented DfE in 2010 in partnership with the University of Sao Paulo. The company launched the Brastemp Inverse Viva! refrigerator that works with an intelligent variable capacity compressor (VCC) to allow low energy consumption.

The product and process life cycle assessment practices are adopted by a minority of the companies interviewed, and they have not yet been fully incorporated. However, this evaluation is extremely important to comprehensively preserve the environment, bearing in mind that all products and services used should be considered from their manufacture to final disposal at the end of their lifespans.

Two practices related to products at the end of their life cycles were predominant at the planning stage or the beginning of implementation when not previously implemented: recycling and/or reusing materials or components from products at the end of their life cycle (Practice 5 – Green manufacturing or remanufacturing) and reverse logistics for the collecting products at the end of their life cycle for recovery, remanufacturing, recycling, or final destination (Practice 4 – Reverse logistics). Recycling and/or reusing materials was implemented by only 20% of the organizations.

The planning and beginning of implementation of reverse logistics in this case actually explains the non-implementation and low value in planning and implementation at the initial stage because it is not possible to recycle and/or reuse products if they are not collected at the end of their life cycle.

Lack of awareness, insufficient communication, fiscal and financial obstacles, and the large amount and low added value of the components are some of the factors that delay realizing the practice of reverse logistics. Consequently, these factors also delay the recycling and/or reuse of product materials at the end of their lifespan.

Brazil also faces a problem of disseminating practices and environmental education due to the country's size and socioeconomic and cultural differences (Demajorovic et al., 2012). In this respect, investments across the national territory are necessary for implementing reverse logistics of electronic wastes.

Public consortia for managing solid wastes are an alternative to municipalities that still have dumps as a method of final disposal and are an important instrument for the economy of scale in managing solid wastes.

In addition to recycling, one of the problems faced in reverse logistics is inadequate selective collection, which is another challenge to be overcome in Brazil. Nonetheless, this context tends to be modified, and the implementation of reverse logistics for electronic wastes tends to be disseminated, according to the National Solid Waste Policy. In fact, the largest companies already have collection points for products no longer being used in the state of São Paulo.

These results show that implementing green practices is an evolutionary process reflected by companies' increasing green capabilities. This capability accumulation process can be represented as a pyramid (figure 3).

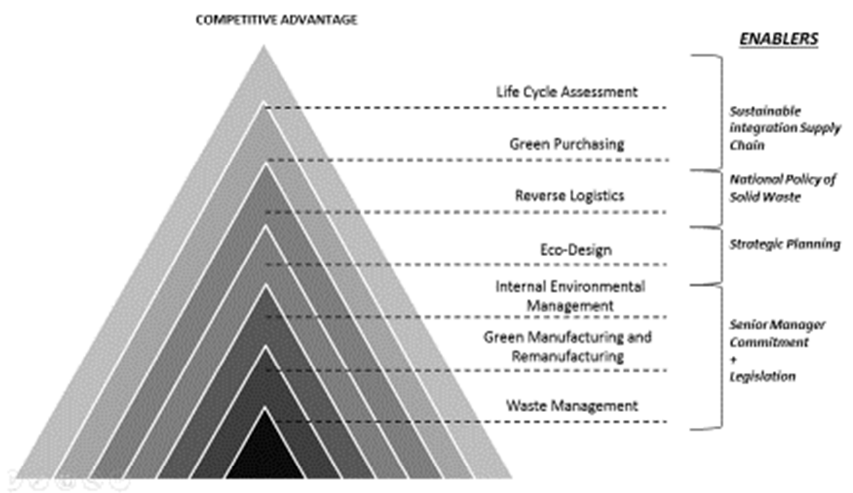

Figure 3 – GSCM pyramid

Implementing these practices starts with decreasing emissions and treating solid and liquid effluents and finishes with integrating the supply chain through life cycle assessment.

GSCM practices require integration and cross-functional cooperation in addition to the commitment of senior managers in order to be implemented. In fact, this result is in line with the findings regarding the

Indian mining scenario studied by Govindan et al. (2016), which showed that top management commitment is driven by external factors such as government policies and regulations. Moreover, senior management is responsible for planning and developing environmental policy and GSCM implementation.

Internal environmental management plays a relevant role in improving enterprise performance in terms of manager commitment and cross-functional cooperation (Hsu and Hu, 2008). All of the companies stated that this commitment is important, even if they are at different levels of implementation of the internal environmental system.

Related to cross-functional cooperation, Whirlpool stated that internal environmental management is facilitated by 35 multipliers and created the Sustainable Committee in 2011 to define goals and approve sustainable strategies transversely inside the firm. In the same way, Muller works as a committee. Electrolux argues that the most difficult point of this cooperation is to achieve commitment from the suppliers. These findings are in line those of Jabbour et al. (2016), who stated that to achieve green performance, companies should emphasize their preference for environmentally appropriate supplier selection.

Considering the internal environmental audits, Whirlpool, Electrolux and Muller are ISO 14001 certified.

From another perspective, the level of adoption of GSCM practices was compared between the companies that have ISO 14001 certification and those that do not have this certification based on the arithmetic average of the collected answers. The results, which are shown in table 3, verify that some variables (highlighted) presented significant differences.

Table 3
GSCM practices among participating companies with and without ISO 14001

PRACTICES	Certified Companies	Non-certified Companies	≠
Internal Environmental Management	98%	45%	53%
Reverse Logistics	85%	48%	38%
Green Purchasing	83%	30%	53%
Ecodesign	93%	60%	33%
Life Cycle Assessment	60%	30%	30%
Waste Management	100%	60%	40%
Green Manufacturing and Remanufacturing	92%	66%	26%

Source: Research data

The variables regarding the practices of eco-design, life cycle assessment, waste management, and green manufacturing and remanufacturing presented differences of up to 50%. Other variables related to practices of internal environmental management, reverse logistics, and green purchasing presented considerable differences, above 60%.

According to González, Sarkis and Adenso-Días (2008), a possible relation is shown between a company that has ISO 14001 certification and the requirements given to the suppliers in terms of environmental issues. This fact is confirmed in table 3, which shows that the companies with ISO 14001 certification have the highest averages of green purchasing compared to the averages from the companies that do not have the certification.

Among the companies with ISO 14001 certification, the practices of internal environmental management and waste management presented an average above 4.67. Therefore, the practices previously mentioned can be considered to have already been consolidated among the ISO 14001-certified companies that participated in this study.

The multinational companies that participated in this research all have ISO 14001 certification. Rao (2007) explains that the certification is justified because the client is located in a distant place, often abroad, making the verification and monitoring of the companies' environmental performance impossible. For this reason, clients prefer a certificate with international accreditation, such as ISO 14001, to ensure good environmental performance from these suppliers and business partners.

However, non-accreditation may be associated with high implementation costs, as mentioned by Pombo and Magrini (2008). These authors suggested that a company should start by introducing a basic environmental management system and then gradually transform it into a more sophisticated system to overcome this barrier.

A Likert scale was adopted to determine the status of GSCM implementation in each company.

The results are summarized in figure 3. The first column shows the manufacturers; the second column shows the constructs to be measured; and the third column shows the implementation status of each practice.

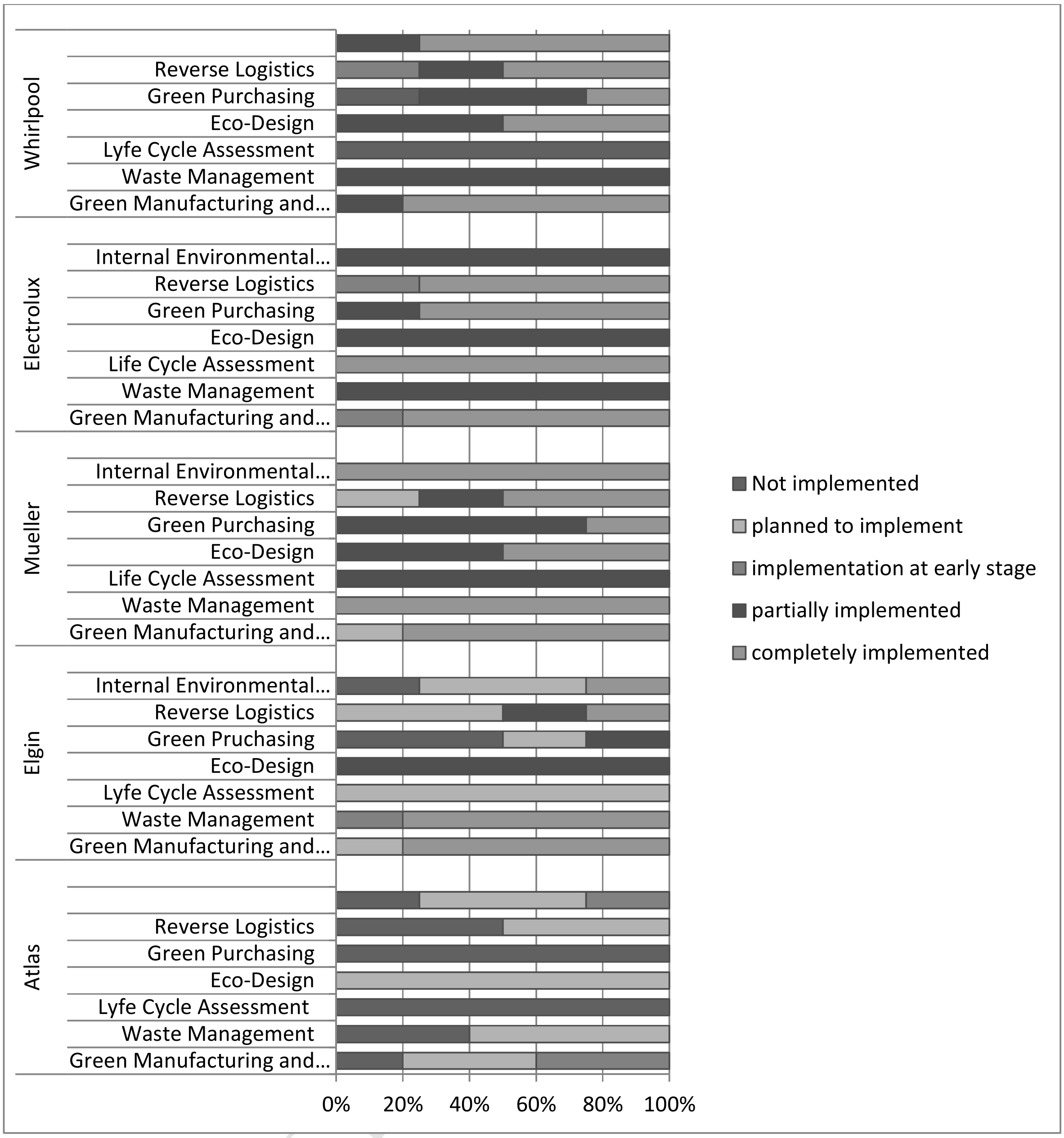

Figure 4 - GSCM practices adopted by manufacturers
Source: Research data

Figure 4 shows that Electrolux, Mueller and Whirlpool are the manufacturers with the most practices implemented. Elgin and Atlas presented less implementation than they claim to be planning. Therefore, the evolution and dissemination of green practices among manufacturers is progressive.

The results present the general status of GSCM implementation in the leading Brazilian home appliance manufacturers. Moreover, the Likert scale presented the importance of a determined green practice and, on the other hand, recognized the points on which manufacturers should put their efforts throughout the process of GSCM implementation.

5 CONCLUSIONS

This research was restricted to home appliance manufacturers from the National Association of Producers of Electronic Goods to understand which GSCM practices are the most disseminated in this industry. As a secondary goal, it identifies the motivators and barriers for implementing these practices. National and international regulatory pressures, marketing strategy, environmental criteria demanded in exportation, and the sustainability culture were noted by the companies as motivating factors in the adoption of environmental practices.

The GSCM practice most widely adopted by home appliance manufacturers is waste management due to the strong influence of Brazilian legislation. Similar conclusions were obtained by Kuei et al. (2015), who noted that the larger Chinese firms in the chains pay more attention to regulatory and public pressures.

The results show that better performance in green practices is associated with large companies, confirming the findings from other studies in Brazil and India (Singh et al., 2014; Teles et al., 2015) addressing the positive relation between company size and commitment to the implementation of environmental practices.

This paper is relevant in terms of the new market demands to fulfill legal requirements and to adopt practices related to supply chain management and its relation to environmental management, especially within the context of an emerging market such as Brazil.

The main contribution of this study is the hierarchical model presented in figure 3. This model provides a structured model for understanding the complexity and implementation of green practices in the Brazilian home appliance supply chain. Thus, this paper extends the literature by adding evidence from an emerging country, as suggested by Mittal and Sangwan (2014). Moreover, another contribution of this paper is providing data that allow companies to evaluate their performance in terms of their adoption of green practices. Figures 3 and 4 presented in this manuscript can be used as a self-diagnostic tool to identify areas that require specific improvements and can indicate GSCM practices that need additional implementation. The degrees of implementing GSCM practices follow theoretical principles in which the internal practices are implemented before the external ones (Jabbour, 2015; Zhu et al., 2013). In this study, green purchasing, eco-design and life cycle assessment are emerging approaches. First, leading manufacturers pressure their suppliers to achieve better environmental performance. Then, buyer-supplier relationships affect GSCM implementation, especially in these practices. In this way, supplier management plays a crucial role in implementing GSCM practices. These results are in line with the Taiwanese electrical and electronic industry. Hsu and Hu (2008) demonstrated that supplier management is one of the most important dimensions for implementing GSCM practices.

Similar to the findings of Jabbour et al. (2016), the results show that the simple publication or initiation of an environmental law such as NPSW is not sufficient to promote an integrated supply chain in terms of sustainable practice implementation.

Although the sample in this study was insufficient, the GSCM pyramid can serve as a foundation for further research exploring the internal structure for GSCM adoption and the relationships with suppliers and customers. Moreover, it would be relevant to validate the extension of the pyramid model to other sectors. In fact, this paper can be considered a basis for developing a new measurement scale model. As noted by Zhu et al. (2008), the validation of the model is an ongoing process and needs to be established over a series of studies that further refine and test the practices across manufacturers and countries.

The pyramid framework is intended to be widely applicable. However, any effort to measure GSCM implementation must consider the specific circumstances of the supply chain that is assessed. In this way, the identified priorities in the pyramid model will vary from sector to sector and will change over time.

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